

# Aging Assessment and Management

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With the rapid advances in technology, we have become increasingly dependent in our daily lives on complex, highly engineered devices and structures. Many of them are expected to operate reliably for years, continuing to perform their function safely and efficiently. Nuclear power plants, aircraft, and highway infrastructures are a few examples of such systems and structures.

A common feature of all of these systems is that they are susceptible to degradation at some level during service.

The Engineering Mechanics and Infrastructure Group at Brookhaven National Laboratory (BNL) has conducted the following aging assessments:

- Active mechanical components, such as pumps, valves, motors, and circuit breakers.
- Passive elements, such as structures, electric cables, and piping.
- Large-scale infrastructure systems, such as buildings and facility-support systems.

To properly manage aging, the risk significance of all environmental and operating stressors must be considered, and proper measures taken to ensure that they are controlled. This requires carefully considering several different factors, starting with design and operation and including such items as maintenance and monitoring.



*Factors to Consider  
in Aging Management*

BNL's approach to the assessment and management of aging is a multi-faceted one ensuring that all essential aspects are addressed:

- **Identification:** A critical step in any aging assessment is to properly identify the component or system of interest and to establish its boundaries and interfaces.
- **Risk Significance:** A risk assessment is undertaken to identify the most risk-significant aging stressors and failure modes for the component or system and the most important sub-components. This approach focuses resources in the most productive areas.
- **Aging Characterization:** The various stressors contributing to degradation are identified and prioritized, and the different aging mechanisms and causes of failure are characterized. This information is at the heart of the aging assessment and helps in developing mitigating measures.

This assessment is made through reviewing and analyzing past operating experience, as well as by testing components and materials.

- **Aging Mitigation:** Once aging degradation has been characterized, current methods of mitigation are reviewed, and any needed improvements are recommended to ensure that aging is properly monitored and managed.

## Capabilities

BNL has all the capabilities necessary to perform complete aging assessments and to develop aging management programs:

- **Engineering Analysis:** BNL's engineering team includes the broad range of expertise needed to make a detailed assessment of aging. The engineering disciplines include mechanical, structural, electrical, and materials engineering.
- **Database Development:** An important tool for exploring past operating experience is a sound, comprehensive database that will facilitate the review and analysis of large amounts of data. BNL has extensive experience in developing computerized databases specifically for this purpose.
- **Equipment Aging:** Testing often is the best approach to properly characterizing the aging symptoms of certain components or materials. BNL's aging

research laboratory can artificially age material samples or whole components to study the effects of various environmental stressors on degradation. Artificial thermal aging to simulate service in high-temperature environments is carried out in BNL's specially controlled and calibrated convection ovens. Radiation aging is also available through BNL collaborators. The hallmarks of aging in electrical equipment can be characterized and tested in BNL's Electric Component Test Facility.

### ***Resources/Facilities***

- ***Electric Component Test Facility:*** This state-of-the-art facility includes capabilities to perform various electrical tests on equipment, including dielectric loss, polarization index, insulation resistance, and Time Domain Reflectometry. The materials testing capabilities available include Oxidation Induction Time/ Temperature, Infrared Spectroscopy, Compressive Modulus, and Elongation-at-Break.
- ***National Synchrotron Light Source:*** This multi-million dollar, world-class user facility provides X-ray, ultraviolet, and infrared light for experimental research on a wide variety of unique materials.
- ***Transmission/Scanning Electron Microscopy:*** BNL has comprehensive facilities to examine microscopic changes in materials that result from degradation and aging.



***Equipment Testing at BNL's  
Electric Component Test Facility***

### ***Selected Accomplishments***

- ▶ Participated over many years in NRC/DOE aging research programs for active mechanical and electrical components, electric cables, building structures, and structural components.
- ▶ Acted as a lead laboratory in electrical field; currently conducting environmental qualification testing of aged electrical cables.
- ▶ Conducted on-site inspections of age-related structural degradation at older nuclear plants, as well as preparing probability-based risk analyses for corroded steel containments.

Currently developing technical guidance for walkdown, inspection, testing, assessment, and repair of degraded structures, including the development of risk- assessment methods.

- ▶ Performing aging assessment and life extension evaluations for nuclear power plants.

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